BEST AVAILABLE COPY

(12) UK Patent Application (19) GB (11) 2 218 580 (13) A

(43) Date of A publication 15.11.1989

(21) Application No 8910355.0

(22) Date of filing 05.05.1989

(30) Priority data
(31) 63061325 (32) 10.05.1988 (33) JP

(71) Applicant
Shin-Etsu Polymer Co. Limited

(Incorporated in Japan)

3-5 Nihonbashi-honcho, 4-chome,
Chuo-ku, Tokyo, Japan

(72) Inventors
Takashi Nogami
Hideki Suzuki

(74) Agent and/or Address for Service
Urquhart-Dykes & Lord
Floor B, Milburn House, Dean Street,
Newcastle-upon-Tyne, NE2 1LE, United Kingdom

(51) INT CL⁴
H01R 11/01

(52) UK CL (Edition J)
H2E EEKA
U1S S2285

(56) Documents cited
WO87/06091 A1 US 4520562 A
I.B.M. Technical disclosure bulletin, vol. 16, no. 7, December 1986, page 3224, "Snap-in board-to-board elastomeric connector"

(58) Field of search
UK CL (Edition J) H2E EEKA

(54) Anisotropic connector

(57) An anisotropic connector comprises an elastomeric base body 2 and conductive wires 3 bonded to the body and exposed above the surface of the body, the wires being more rigid than the elastomer. The elastomer is preferably silicone and the wire may be of a variety of cross sections of Ni, brass, stainless steel, phosphor bronze, Au, Al, conductive plastics, carbon, or insulating strands of plastics or glass coated with metal, alloy or a conductive resin. A rigid core 4 may be provided.

FIG.4b

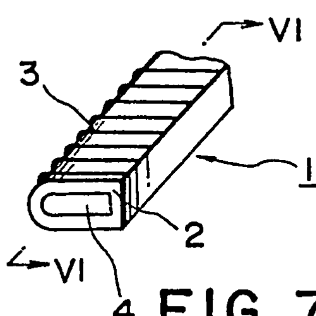


FIG.6

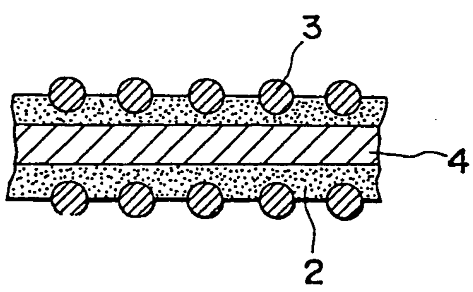


FIG.8a

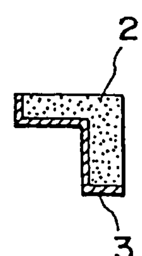


FIG.7

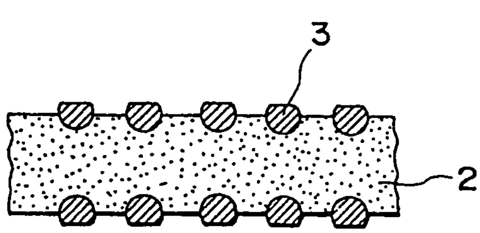


FIG.8c

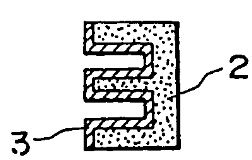
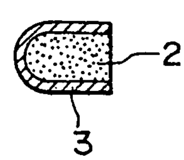


FIG.8f



GB 2 218 580 A

2218580

FIG. 1a

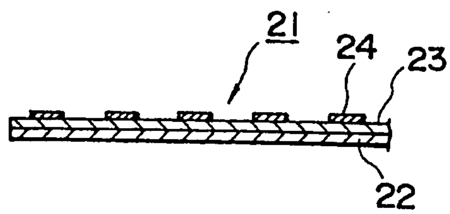


FIG. 1b

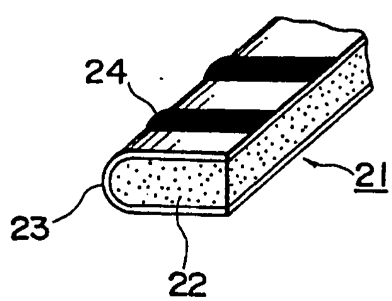


FIG. 1c

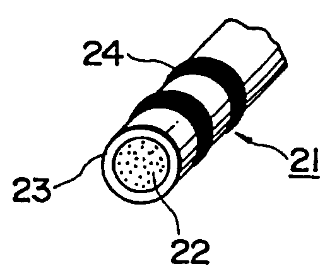


FIG. 2a

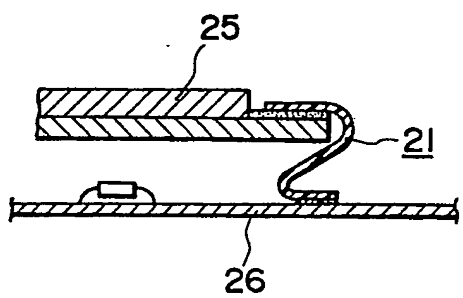


FIG. 2b

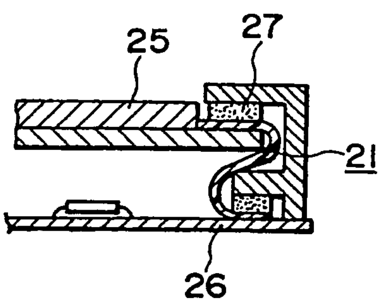


FIG. 2c

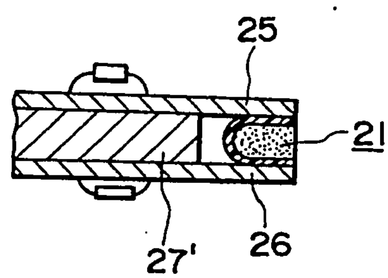


FIG. 3

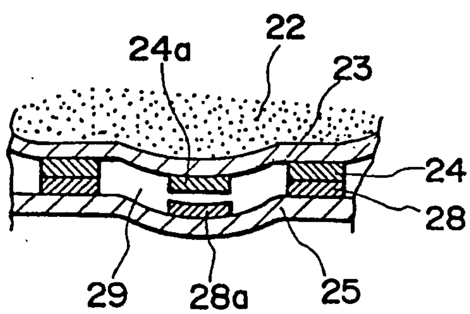


FIG. 4a

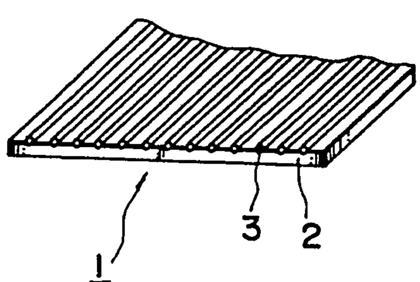


FIG. 4b

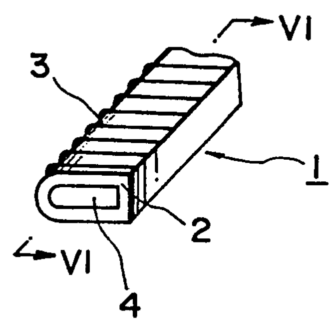


FIG. 5

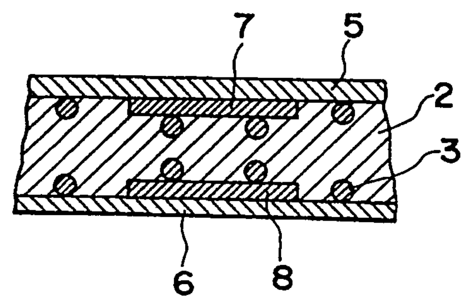


FIG. 6

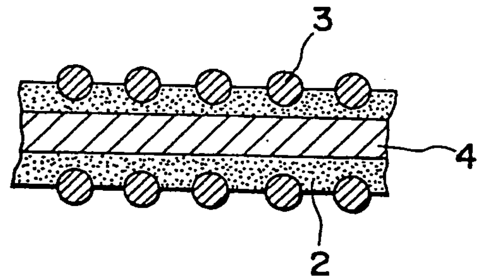


FIG. 7

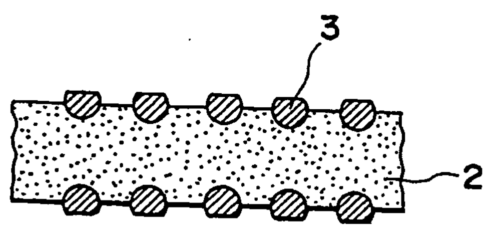


FIG.8a

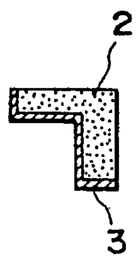


FIG.8b

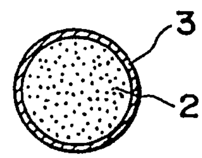


FIG.8c

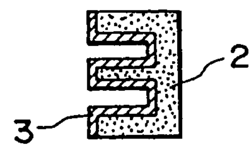


FIG.8d

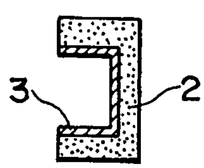


FIG.8e

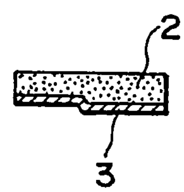


FIG.8f

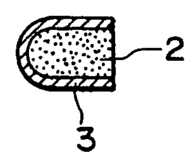


FIG. 9a

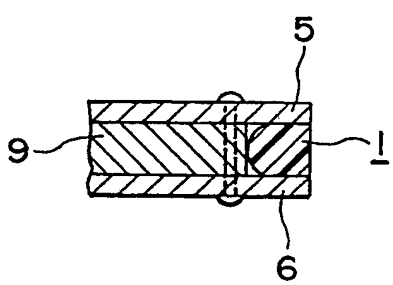


FIG. 9b

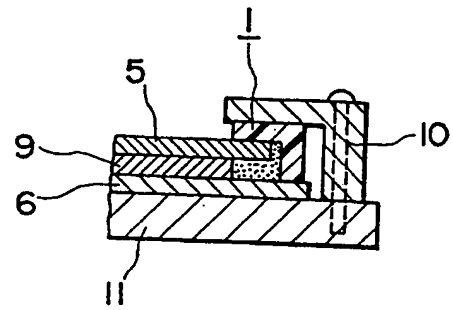


FIG. 9c

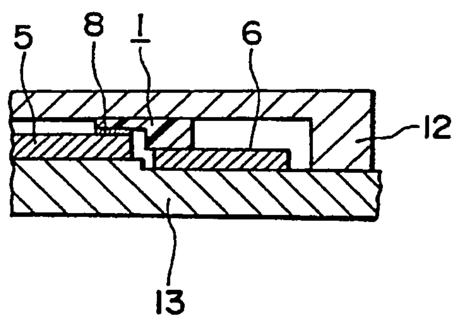


FIG. 9d

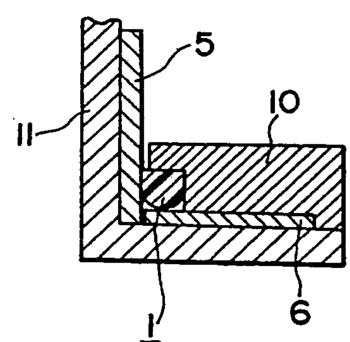


FIG. 9e

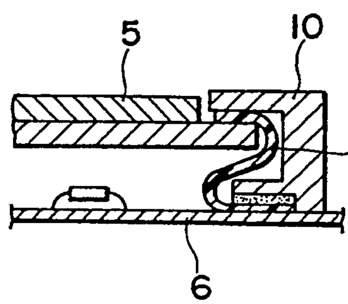


FIG. 9f

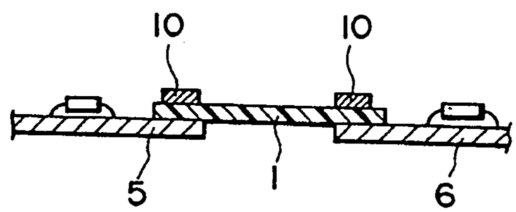
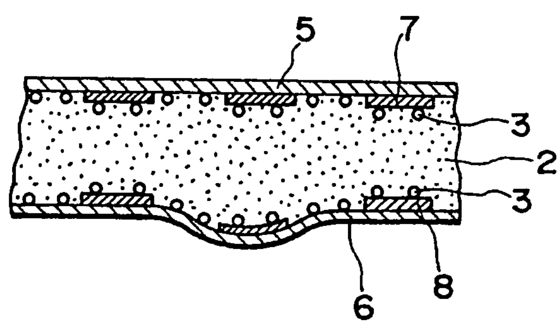


FIG. 10



AN INTERCONNECTOR

BACKGROUND OF THE INVENTION

The present invention relates to an interconnector or, more particularly, to an interconnector suitable for making electrical connection between the connecting terminals of various kinds of display units such as LCDs, ELDs, plasma displays and the like and the terminals on a circuit board mounting the driving circuits for the display unit or between groups of connecting terminals on two circuit boards for an assembly of electric circuits.

Various types of interconnectors are used in the prior art for the above mentioned purpose including those illustrated in Figures 1a, 1b and 1c by a cross sectional view (Figure 1a) or by a perspective view (Figures 1b and 1c). These interconnectors 21 in general are constructed of a base body 22 made of an electrically insulating elastomer such as silicone rubbers which is provided with a copper-foiled covering layer 23 of a polyester resin or polyimide resin followed by patternwise etching of the copper foil to form electroconductive lines 24. These interconnectors 21 are used in such a manner as illustrated in Figures 2a, 2b and 2c by a cross sectional view as being interposed between and press-contacted with a fixed substrate board 25 and a circuit board 26.

The usefulness of these conventional interconnectors is, however, decreasing less and less in recent years because of the

incompatibility with the demand in the modern electronic technology which requires higher and higher density in the arrangement of the connecting terminals on the circuit boards mountable in a more and more compact electronic instrument. This is partly because the plastic films of polyester, polyimide and the like have a relatively high rigidity or Young's modulus approximating that of copper so that the undulation of or level difference on the surface of the circuit boards cannot be fully followed up by the deformation of such a plastic film and, consequently, the copper-foiled conduc-tive lines to greatly decrease the reliability in the electric connec-tion obtained by using such an interconnector. When an interconnector of which the conductive lines 24 are formed by an etching treatment of a copper foil on the plastic film 23 is in use by being mounted on a circuit board 25 as is illustrated in Figure 3, moreover, a space 29 larger or smaller is formed between the interconnector 21 and the circuit board 25 on the areas excepting the electrodes 28 on the circuit board and the conductive lines 24 on the interconnector and the atmospheric moisture readily intrudes into this space 29 to cause corrosion of the electrodes 28 leading to a decrease in the serviceable life of the assembly as a whole. In addition, the slidable surface condition of the plastic film 23 and the conductive lines 24 sometimes causes electric disconnection between the conductive line 24a and the eledctrode 28a as illustrated in Figure 3 when the assembly receives a mechanical shock or vibration to cause sliding between the contacting surfaces or slackening of the plasttic film 23. In addition, assemblage of circuit

boards sometimes requires insertion of a cushoning member 27 or a spacer 27' illustrated in Figures 2b and 2c in order to ensure exactness in the positioning of the interconnector 21 relative to the arrangement of the terminal electrodes 28 on the circuit board 25. Accordingly, it is eagerly desired to develop an interconnector freed from the above described problems and disadvantages in the conventional interconnectors.

SUMMARY OF THE INVENTION

The present invention accordingly provides a novel interconnector freed from the above described problems and disadvantages in the conventional interconnectors, which comprises:

(a) a base body made of an electrically insulating rubbery elastomer; and

(b) a plurality of electroconductive fine wires made of a material having a rigidity higher than that of the rubbery elastomer to the surface of the base body in such a manner that at least a part of each of the wires is exposed bare.

BRIEF DESCRIPTION OF THE DRAWING

Figures 1a, 1b and 1c are each a cross sectional view or a perspective view of a conventional interconnector and Figures 2a, 2b and 2c and Figure 3 are each a cross sectional illustration for the manner of using a conventional interconnector.

Figures 4a and 4b are each a perspective view of an inventive interconnector and Figure 5 is a cross sectional illustration of the manner of using the inventive interconnector.

Figures 6 and 7 are each a cross sectional view of an inventive interconnector illustrating the electroconductive wires embedded in the base body.

Figures 8a to 8f are each a cross sectional view of a variation of the inventive interconnector. Figures 9a to 9f and Figure 10 are each a cross sectional view illustrating the manner of using the inventive interconnector.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

As is described above, the base body of the inventive interconnector is made, in place of the plastic films in the conventional interconnectors, of an electrically insulating rubbery elastomer such as a synthetic rubber having good flexibility and conductive lines thereon are formed of fine metal wires bonded to the base body with at least a part of the surface exposed bare. In this construction of the interconnector, the rubbery elasticity with flexibility of the base body has an effect to compensate for the undulation or level difference on the surface of circuit boards so that a high reliability is obtained in the electric connection made by using the interconnector. Furthermore, little or no space is left between the interconnector and the circuit board so that the troubles caused by

the intrusion of moisture into such a space can be completely avoided and the contacting surfaces are freed from the problem of slipping each on the other.

To give a more detailed explanation of conventional interconnectors in this regard, it is usual that the height of the metal foil or wire is in the range from 15 to 40 µm and the arrangement pitch thereof is at least 0.2 mm so that the electric connection with electrodes is obtained with only one third or smaller of the width of the metal foil as compared with the width of each electrode. In an interconnector having a copper foil mounted with a interposed plastic film as is illustrated in Figure 1, pressing-down of the interconnector against an array of electrodes causes depression of not only a single copper foil line but also the adjacent copper foil lines in an uncontrollable extent. In other words, each of the copper foiled lines is depressed not independently but in conjunction with the adjacent ones to cause slackening as is illustrated in Figure 3.

In the following, description is given of the inventive interconnector with reference to the accompanying drawing illustrating typical embodiments of the invention.

Figures 4a and 4b are each a perspective view of the inventive interconnector 1 which is formed by providing an electrically insulating elastomeric sheet 2 with a plurality of electroconductive fine wires 3 on the surface. It is optional as illustrated in Fig-

ure 4b that, instead of forming the base body entirely of a rubbery elastomer, the insulating elastomeric sheet 3 is accompanied by a core member 4 made of a rigid plastic resin or a like material and extending in the longitudinal direction of the interconnector 1 to impart adequate rigidity to the interconnector 1 as a whole with an object to facilitate handling and to prevent warping of the interconnector 1.

Figure 5 is a cross sectional illustration of the interconnector 1, for example, shown in Figure 4b under use as sandwiched between two circuit boards 5, 6 with the conductive lines 3 being in contact with the terminal electrodes 7 and 8 on the circuit boards 5 and 6, respectively. When the circuit boards 5 and 6 are pressed together under an appropriate force by utilizing the rubbery resilience of the interconnector 1, reliable electric connection can be established between the conductive lines 3 and the terminal electrodes 7 and 8.

Various kinds of electrically insulating rubbery elastomer can be used for making the insulating base body 2 in the inventive interconnector 1 including synthetic rubbers such as polychloroprene rubbers, polybutadiene rubbers, styrene-butadiene copolymeric rubbers, nitrile rubbers, butyl rubbers, ethylene-propylene copolymeric rubbers, acrylic rubbers, fluorinated urethane rubbers, silicone rubbers and the like, of which silicone rubbers are preferred in respect of the durability, high electric insulation, sta-

bility against environmental influences and workability. If desired, these rubbery materials are used in the form of a foamed cellular porous body of open cells or closed cells. As a criterion for the selection of the rubbery materials, the material should preferably have a hardness of 20 to 80 in the JIS scale of hardness A in respect of the good cushoning effect and full adaptability to warping or undulation of circuit boards. The rubbery material also should have a 100% modulus not exceeding 100 kgf/cm^2 or, preferably, not exceeding 50 kgf/cm^2. A rubbery material having a 100% modulus in the range from 10 to 70 kgf/cm^2 can be selected from the above named synthetic rubbers.

The type of the silicone rubber composition for making the above mentioned base body 2 is not particularly limitative including those compounded with an organic peroxide as a crosslinking agent and curable by heating, those curable at room temperature by the crosslinking reaction between silanolic hydroxy groups of the formula $-SiR_2-OH$ at the molecular chain ends of an organopolysiloxane and the hydrolyzable groups in an organosilane or organopolysiloxane compounded as a crosslinking agent and those curable by the mechanism of so-called addition reaction or hydrosilation reaction between vinyl groups in an organopolysiloxane and the silicon-bonded hydrogen atoms in an organohydrogenpolysiloxane taking place in the presence of a platinum compound as a catalyst. The last-mentioned addition reaction-curable silicone

rubbers are preferred in view of the rapidness of the curing reaction at a relatively low temperature.

The base body 2 made of an insulating rubbery elastomer may have various configurations provided that the configuration has a pair of approximately parallel surface planes at which the interconnector is sandwiched between two circuit boards including sheets, blocks, rods and so on.

Electroconductive fine wires 3 are bonded to the above mentioned approximately parallel surface planes of the base body 2 to form the inventive interconnector 1. The fine wires 3 of course can be formed of a metal or an alloy such as nickel, brass, stainless steel, tungsten, phosphor bronze, gold, aluminum and the like having a relatively high rigidity as compared with the rubber-made base body 2 having a Young's modulus of at least 10^3 kgf/cm^2 or, preferably, at least 10^4 kgf/cm^2. Practically, a difference of at least 10^2 kgf/cm^2 is desirable between the moduli thereof. Filaments made of an electroconductive plastic resin and carbon fibers can be used in place of metallic wires. If desired, metallic wires can be replaced with electrically insulating filaments of a plastic resin or glass coated or plated with a metal or alloy, a conductive resin or a conductive coating composition. In short, selection of the conductive material should be made in consideration of the mechanical and electrical properties as well as costs of the material. So-called electroconductive rubbers prepared by compounding and dispers-

ing conductive particles of carbon, graphite or metal in an insulating matrix of rubber are not suitable as the conductive material of the fine conductive lines because difficulties are encountered in shaping and winding works of such fine lines of a conductive rubber. Following are the values of the Young's modulus of several metals and alloys suitable as a material of the conductive fine wires: nickel ca. 2.1×10^6 kgf/cm^2; brass ca. 1×10^6 kgf/cm^2; stainless steel ca. 2×10^6 kgf/cm^2; gold ca. 1×10^6 kgf/cm^2; tungsten ca. 4×10^6 kgf/cm^2; aluminum ca. 0.8×10^6 kgf/cm^2; carbon fiber ca. 2×10^6 kgf/cm^2; nickel-plated glass fiber ca. 7.4×10^4 kgf/cm^2; nickel-plated polyester fiber ca. 2.1 to 4.2×10^4 kgf/cm^2; and gold-plated nylon fiber ca. 1.8 to 2.8×10^4 kgf/cm^2.

The arrangement of the electroconductive fine wires 3 on the surface of the elastomeric base body 2 is not particularly limitative. As is illustrated in Figure 6, the fine wires can be aligned in parallel with each other on the surface of an insulating elastomeric sheet 2 as partly embedded therein. Although the cross sectional configuration of each fine wire is not particularly limitative including irregular, star-like, elliptical, square, arch-like, sector-like and semi-circular cross sections according to need, the wires 3 each preferably have a circular cross section in view of the accuracy in the cross section, strength to withstand bending and productivity as well as good workability in the bonding work of them to the surface of the base body 2, good sinking behavior into the elastomeric base body 2 when under pressure and accuracy in align-

ment. It is sometimes advantageous that, as is illustrated in Figure 7, each of the wires having a circular cross section has a flat surface by shaving off in the longitudinal direction in respect of the reliability in the electrical contact with the surface of the terminal electrode of the circuit board at which the conductive lines of the interconnector are press-contacted.

The conductive fine wires 3, assumed to have a circular cross section, have a diameter in the range from about 1 μm to a few millimeters or, usually, in the range from 5 μm to 500 μm depending on the intended application of the interconnector. It is of course that the wire diameter should be smaller than the arrangement pitch of the terminal electrodes on the circuit board to be electrically connected and also smaller than the dimension or, preferably, one-third of that in the press-contacting direction. The arrangement pitch of the conductive fine wires should also be one-half or smaller of the arrangement pitch of the terminal electrodes on the circuit board. Practically, the diameter of the wires for the conductive lines is smaller than one-half of the width of the terminal electrode to be contacted therewith and the conductive lines should be arranged in a pitch as small as possible in so far as the elastic resilience thereof is not unduly decreased. In this connection, the gap space between two adjacent terminal electrodes is desirably at least twice of the arrangement pitch of the conductive fine wires. These conditions are requird in order to ensure independent bending behavior of each of the conductive fine wires to comply with the

depressing deformation of the less rigid base body when the interconnector is in use by press-holding. The most basic embodiment of the inventive interconnector is as illustrated in Figure 4a.

It is optional in order to improve the adhesive bonding between the insulating elastomeric base body and the conductive fine wires forming the conductive lines 3 that the surface of the wires is coated with a suitable coupling agent in a thickness not to unduly decrease the electric conductivity of the wire surface or the conductive surface layer on the wire is formed of a composition compounded with a coupling agent. Various kinds of coupling agents are known and used in accordance with the type of the polymeric material. When the insulating elastomeric base body is made of a silicone rubber, for example, known coupling agents include silane-type ones such as 3-glycidyloxypropyl trimethoxy silane, vinyl trichlorosilane, N-2-(aminoethyl)-3-aminopropyl trimethoxy silane and the like, of which 3-glycidyloxypropyl trimethoxy silane is preferred. When a coupling agent is utilized appropriately, the adhesive bonding can be greatly improved between the base body and the conductive lines so that the danger of line displacement in the interconnector under use by press-contacting can be minimized even when the area for the adhesive bonding is considerably small.

The use of a rigid core member 4, which is, for example, in the form of an elongated rod illutrated in Figure 4b is not essen-

tial but desirable, especially, when the insulating elastomeric base body is so flexible as to cause a trouble in handling during the work of assemblage or the interconnector is so elongated as to cause warping or distortion larger than negligible. Various kinds of materials can be used for shaping the core member 4 including plastic resins such as polyethylenes, polypropylenes, polystyrenes and the like having a relatively high rigidity and relatively soft metals and alloys. It is of course important that the independent bending behavior of each of the conductive fine wires is not disturbed from the adjacent ones by the use of such a core member.

The interconnector of the invention may have a variety of structures and configurations depending on the intended application thereof in assemblage of an electronic component with an essential requirement that the interconnector 1 can be press-contacted with the terminal electrodes of a circuit board to be electrically connected with the interconnector. It is a desirable condition that, as is illustrated in Figure 5, the peripheral portion of the surface of the conductive lines 3 is approximately at the same level as or flush with the surface of the base body 2 when the conductive lines sink into the elastomeric base body by pressing in contact with the terminal electrodes 7 and 8 on the circuit boards 5 and 6 in order to obtain a packing effect without leaving a void space by keeping a sufficient contacting area between the conductive lines 3 and the terminal electrodes 7,8. In this regard, it is preferable that each of the conductive fine wires 2 is bonded to the elastometric base body

2 as partly embedded therein in such a depth that at least one-sixth or, preferably, at least one-third but five-sixths or less of the diameter thereof perpendicular to the surface of the base body is below the surface level of the base body 2 in an unpressed state since too small embedding depth of the wires 3 in the base body 2 may cause disadvantages that an unduly large pressing force is required in press-contacting the interconnector with a circuit board and eventual distortion of the electric circuit on the circuit board.

The interconnector of the present invention may have a variety of shapes and configurations without particular limitations provided that the interconnector can be press-contacted reliably and conveniently with the array of the terminal electrodes on a circuit board to be electrically connected therewith. Typically, the interconnector has an elongated configuration having an appropriate cross section illustrated in Figures 8a to 8f. Figures 9a to 9f are each a cross sectional illustration of one of these various interconnectors 1 of the invention under use for electrically connecting two circuit boards 5 and 6 as built in a casing 11 or a combination of an upper casing 12 and lower casing 13 by using, when necessary, a spacer 9 and a press-contacting holder 10.

When an electronic unit is assembled by using the inventive interconnector as illustrateed in Figures 9a to 9f, very reliable electric connection can be obtained between two arrays of terminal electrodes on two circuit boards even when the circuit board

has undulation or level differences as is illustrated in Figure 10 because such a disturbing influence can be fully absorbed by the elastic resilience of the elastomeric base body even without using any cushoning member. Furthermore, the electric connection between the inventive interconnector and a circuit board can be established without leaving any void space therebetween because of sinking of the conductive lines into the elastomeric base body so that the electric connection is free from the adverse influences of moisture intruding into such an otherwise formed void space to be imparted with greatly increased serviceable life in addition to the increased resistance against mechanical shocks when the assembly is dropped on the ground or is hit against a hard body.

Following is an example to illustrate the inventive interconnector in more detail.

A sheet-like rubbery base body having a thickness of 1 mm was shaped by molding a silicone rubber compound prepared by compounding 100 parts by weight of a commercially available silicone rubber compound (KE 151U, a product by Shin-Etsu Chemical Co.) with 2 parts of a curing agent (C-2, a product by the same company, supra) and 5 parts by weight of a silane coupling agent (KBM 503, a product by the same company, supra). Fine nickel wires having a diameter of 40 μm and an elastic modulus of 2.1×10^6 kgf/cm^2 were arranged in parallel on the surface of the uncured base body at a pitch of 0.4 mm and press-bonded to the base body in

a hot press at 120 °C for 10 minutes under a pressure of 20 kgf/cm^2 to effect curing of the silicone rubber.

The 100% modulus of the cured base body in the thus obtained interconnector was 25 kgf/cm^2. Each of the fine nickel wires bonded to the surface of the base body was protruded by 10 μm above the surface. When this interconnector was used for electrically connecting two printed circuit boards on which the terminal electrodes each having a width of 0.8 mm were arranged at a pitch of 1.6 mm, the contact resistance on each terminal electrode was 50 m ohm or smaller and the curface of the interconnector was in close contact to the surface of the circuit board without leaving a space therebetween which might be subject to intrusion of atmospheric moisture.

WHAT IS CLAIMED IS:

1. An interconnector which comprises:
(a) a base body made of an electrically insulating rubbery elastomer; and
(b) a plurality of electroconductive fine wires made of a material having a rigidity higher than that of the rubbery elastomer bonded in alignment to the surface of the base body in such a manner that at least a part of each of the wires is exposed bare above the surface of the base body.

2. The interconnector as claimed in claim 1 wherein the electrically insulating rubbery elastomer is a silicone rubber.

3. The interconnector as claimed in claim 1 wherein the electroconductive fine wires each have a circular cross section.

4. The interconnector as claimed in claim 3 wherein the electroconductive fine wires each have a diameter in the range from 5 µm to 500 µm.

5. The interconnector as claimed in claim 3 wherein the electroconductive fine wires are each embedded in the base body in such a depth that at least one-sixth but five-sixths or less of the diameter perpendicular to the surface of the base body is below the surface level of the base body.

Published 1989 at The Patent Office, State House, 66/71 High Holborn, London WC1R 4TP. Further copies may be obtained from The Patent Office. Sales Branch, St Mary Cray, Orpington, Kent BR5 3RD. Printed by Multiplex techniques ltd, St Mary Cray, Kent, Con. 1/87